Research Note 85-92

CHECK LIST FOR SMALL ARMS RESEARCH DESIGN

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Researchers in the field of small arms (whether in uniform or not) often fall into one of two categories. Either they are small-arms subject matter experts (SMEs), who know much about small arms, but little about experimentation and the design of research; or they are scientists, who know a great deal about experimentation, but little about the variables that are important to the users of small arms. This report is intended to provide meaningful information to each of these groups. It gives the SME a very short course in, and overview

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20. (continued)

of, experimental design. Various techniques that the researcher can use to gain control of a field setting are discussed. For the scientist, on the other hand, a list of important variables in the marksmanship and small arms domain is provided.

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The most fundamental thing to remember when designing quality research is that a clearly worded question must be formulated before the design can be addressed. The question must always determine the design, not vice versa. The question should be formulated in the following simple form:

What is the effect of "X" on "Y"?

Where "X" is the independent variable and "Y" is the dependent variable.

In situations with more than one question, the following points should be considered:

1. Decide if each of the questions is necessary.
2. Consider asking the most important question first.
3. Consider asking the most fundamental question first.
4. Consider asking the most simple or "doable" question first.
5. Remember that a series of simple questions is usually superior to a single complex question.

Once the question has been created, the design will logically follow. The most important task in experimental design is to precisely measure the independent and dependent variables while accounting for all other variables which could possibly influence the dependent variable. Control is a key word. There are different strategies for controlling the unwanted effects of nuisance variables. The methods listed in the following paragraphs are discussed in detail by most research design texts (e.g., Robinson, 1976; Myers, 1979; Kerlinger, 1973; etc.).

<u>Independent Variable (IV)</u> If a variable is one that is of primary concern in the research (i.e., the variable whose effects are being studied), then that variable becomes the IV. The IV is always carefully controlled and manipulated in the experiment.

<u>Randomization (RAND)</u> This is probably the most commonly used (and misused) technique for controlling the effects of a variable. For example, if one wants to control for the effects of having troops from different companies, he/she could randomly assign all troops to the various experimental conditions. The problem here is that one must follow the established guidelines for randomization (i.e., insure that each event, subject, etc., has equal chance of being assigned to a given condition). To accomplish this, tables of random numbers are commonly used. It is important to remember that randomization does not necessarily eliminate the problem. Rather, randomization reduces the chances of a nuisance variable severely influencing the outcome of the experiment to some chance level.

Constancy (CON) The unwanted effects of a variable can be controlled by keeping that variable constant for all conditions. For example, if one is concerned that different shooting lanes might affect scores, one could simply require all subjects to fire on the same lane. Two other ways of achieving constancy with subject variables are matching and blocking. Matching is an attempt to equate groups by assigning subjects to conditions on the basis of how they have scored on a variable that is known to be highly correlated with the dependent variable. For example, assigning the two best shooters to opposite teams, two worst shooters to opposite teams, and etc., is an attempt to equate the quality of the two teams. (Notice that we are assuming that the subjects' past performance, e.g., number of hits in the past, is correlated with their performance in this experiment.) Blocking is an attempt to eliminate some of the subject variability by placing subjects of similar backgrounds, abilities, etc., in the same groups (e.g., troops scoring in the top third are placed in one group, troops scoring in the second third are placed in another group, and etc.). Analysis of blocked designs becomes cumbersome so it is probably wise to consult a design expert.

Elimination (ELIM) In order to reduce the effects of an unwanted variable, one simple strategy is to remove that variable from the situation. Obviously, if one is concerned about the unpredictable effects of weather conditions on training research, one could simply move the training inside (if possible).

Statistical Control (STAT) There are statistical analyses that can accomplish approximately the same thing as matching (see above). These analyses attempt to equate the different groups on the basis of some correlated variable (called the covariate). This approach involves fairly sophisticated statistical analyses and it is probably best to consult an expert.

Correlation and Regression Analysis (COR) If there are variables of any current or future interest (aside from the independent and dependent variables), then these variables should definitely be measured and systematically recorded for analysis. Either planned or ex post facto correlational analyses can often unveil interesting and important relationships. One can often economize by "packing" experimental investigations with correlational investigations. It is probably wise to consult a design expert if correlation techniques are to be applied because: a) selection of appropriate correlation-regression analysis is crucial, b) there are many potential pitfalls in conducting such analyses, and c) there are many potential pitfalls in interpreting such analyses.

On the following pages a matrix is provided that lists a number of the most common variables that must be dealt with in research on small arms. This list is not comprehensive; your situation may require you to add some variable(s) to this list. The purpose of the matrix is to force the user to decide whether each of these common variables is relevant in this specific situation and how the user intends to deal with it.

	Relevant (Yes or No)	Measurable? (Yes or No)	IV	RAND	CON	ELIM	STAT	COR	Comments and/or List
Situational Variables									
Geographic Region (hills, swamp, etc.)									
Urban/Rural									
Weather									
Temperature									
Precipitation									
Conditions (muddy, dry, flodded, etc.)									
Wind									
Visibility (day, fog, smoke, night, flares, NV devices)									
NBC									
Extended Operations									
Posture (offensive/defensive)									
Movement/Stationary									
Amount of Gear									
Danger (perceived, actual, simulated)									
Political Considerations									
Experimenter									
Time of week, year, etc.									
Availability of Training Areas, Training Aids, etc.									
Other?									
Soldier Variables									
Level of Expertise									
Unit (combat arms/support/combat support)									
Homogeneous/Heterogeneous									
Degree of Stress (mental)									
Degree of Stress (physical)									
Sex									
Volunteer/Assigned									
Morale									
Mental Aptitude									
Physical Aptitude									
Screened/Arbitrarily Assigned									
Physiological (hunger, thirst, etc.)									
Presence/Absence (for all periods)									
Background Variables									
Previous Related Training and/or Experience									
Related Scores from Training, Tests, etc.									
Other?									

	Relevant (Yes or No)	Measurable? (Yes or No)	IV	RAND	CON	ELIM	STAT	COR	Comments and/or List
Training Variables									
Amount									
Distribution									
Quality									
Trainer/Trainee Ratio									
Feedback Quality									
Feedback Quantity									
Individual/Team									
Communication Systems									
Time Limitations (research)									
Time Limitations (period)									
Time Limitations (program)									
Space Limitations									
Simulation									
Visual Aids									
Charts									
Modeling									
Type of Learning (motor, verbal, cognitive)									
Tests (quantity)									
Tests (duration)									
Tests (density)									
Practice (unmeasurable)									
Safety Requirements									
Current/Proposed Training Doctrine									
Training Site (school, unit, etc.)									
Type of Unit (Mech., Inf., etc.)									
Task Difficulty									
Distance to Target									
Moving/Stationary Targets									
Moving/Stationary Delivery									
Difficulty									
Sophistication of Weapon System									
Others?									
Concurrent Training									
Others?									

	Relevant (Yes or No)	Measurable? (Yes or No)	IV	RAND	CON	ELIM	STAT	COR	Comments and/or List
Trainer Variables									
Level of Expertise									
Morale									
Turbulence									
Sex									
Degree of Stress (mental)									
Degree of Stress (physical)									
Background Variables									
Others?									
Weapon System Variables									
Mode of Weapon Support (tripod, hand held, etc.)									
Firing Position (prone, foxhole, etc.)									
Pre-zeroed									
Quality of System									
General Knowledge of Weapon System									
Stage of Weapon System Development									
Mode of Firing (automatic, semiautomatic, etc.)									
Maintenance (prior)									
Maintenance (during)									
Availability of Weapon System									
Night Vision Device(s)									
Ammunition									
Type									
Quality									
Quantity									
Variability									
Cost									
Availability									
Others?									
Ballistics									
Temperature									
Precipitation									
Weather Conditions									
Wind									
Gravity									
Air Pressure									
Others?									
Single/Multiple Weapon Systems									
Others?									

Dependent Variables

- ______ Per Cent Hits
- ______ Distance from Center of Target (no direction)
- ______ Distance from Center of Target (with direction)
- ______ Latency
- ______ Number of Rounds Delivered
- ______ Go/No Go
- ______ Performance on Paper and Pencil Tests
- ______ Performance on Motor Performance Tests (assembly, disassembly, maintenance, etc.)
- ______ Attitudes of Trainees
- ______ Attitudes of Trainers
- ______ Others?

CHECK LIST OF IMPORTANT CONSIDERATIONS

_____ Have you considered safety?
_____ Have you considered the time limitations for the research?
_____ Have you coordinated with the relevant decision makers?
_____ Have you coordinated with the relevant trainers?
_____ Have you coordinated with the subject population?
_____ Are you personally able to validate all measurements?
_____ What degree of control do you have in the design stage?
_____ What degree of control do you have in the data acquisition stage?
_____ What degree of control do you have in the data analysis stage?
_____ What degree of control do you have in the reporting stage?
_____ Have you considered implementation problems?
_____ Have you considered implementation strategies?
_____ Were you present during the data collection?
_____ Did you brief the trainers?
_____ Did you debrief the trainers?
_____ Did you ask the trainers about problems or for suggestions?
_____ Did you include the trainers in the research process?
_____ Did you ask the trainees about problems or for suggestions?
_____ Did you triple check the data analysis?
_____ Have you considered how this system will coordinate with other systems?
_____ Was there a high degree of cooperation?

MISCELLANEOUS POINTS ON DESIGN

1. Always try to get validated pretest scores on all subjects under identical conditions. The posttest (collection of the dependent variable) will be the same for all subjects.

2. Keep the number of subjects in each group equal.

3. When possible (especially when the number of subjects is small), try to obtain scores from all subjects in all conditions (this is called repeated measures).

4. In repeated measures designs either randomize the order that the conditions are presented or "counterbalance" (e.g., have half the troops shoot the 100 meter target followed by the 200 meter target and the other half shoot the 200 meter target followed by the 100 meter target). Randomization and counterbalancing reduce the differential transfer effects that could occur as a result of repeated measures.

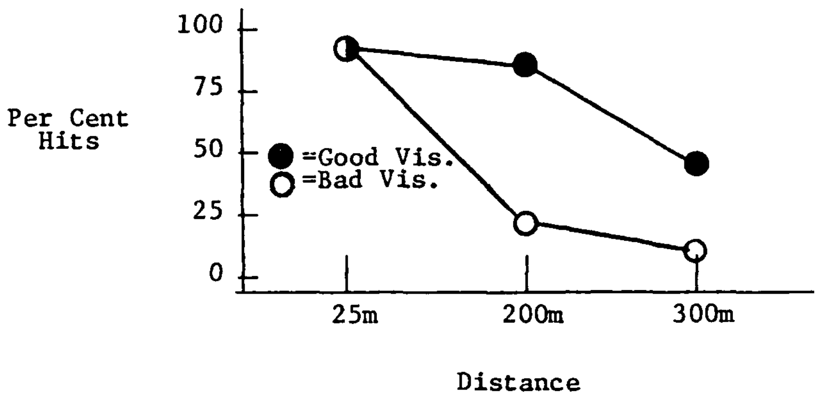
5. When two questions are being asked simultaneously (e.g., what is the effect of visibility on accuracy and what is the effect of distance to the target on accuracy), a matrix should be formed with all levels of one variable (e.g., good or poor visibility) on one dimension, and all levels of the second independent variable (e.g., 25m, 200m, and 300m) as the other dimension:

		Distance		
		25m	200m	300m
Visibility	Poor (Fog)			
	Good			

The above design is called a "factorial design". It is important that (if possible), equal sized groups of subjects be assigned to all possible combinations of visibility and distance (i.e., to each cell in the matrix). Statistical analysis of a design like this allows one to answer at least three questions:

1. What is the effect of distance on accuracy?
2. What is the effect of visibility on accuracy?
3. What are the <u>joint</u> effects of distance <u>and</u> visibility on accuracy?

The third question is a product of the factorial design that allows the user to analyze "interactions". An interaction between two variables means that the effect of one variable depends on the level of the second variable. For example, an interaction is likely to be found in the above example. The graph below indicates the presence of an interaction (i.e., the effects of visibility depends on distance from the target). The hypothetical results below show that there was no effect of poor visibility (e.g., fog) at close range but a very large effect due to fog at the longer ranges.



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